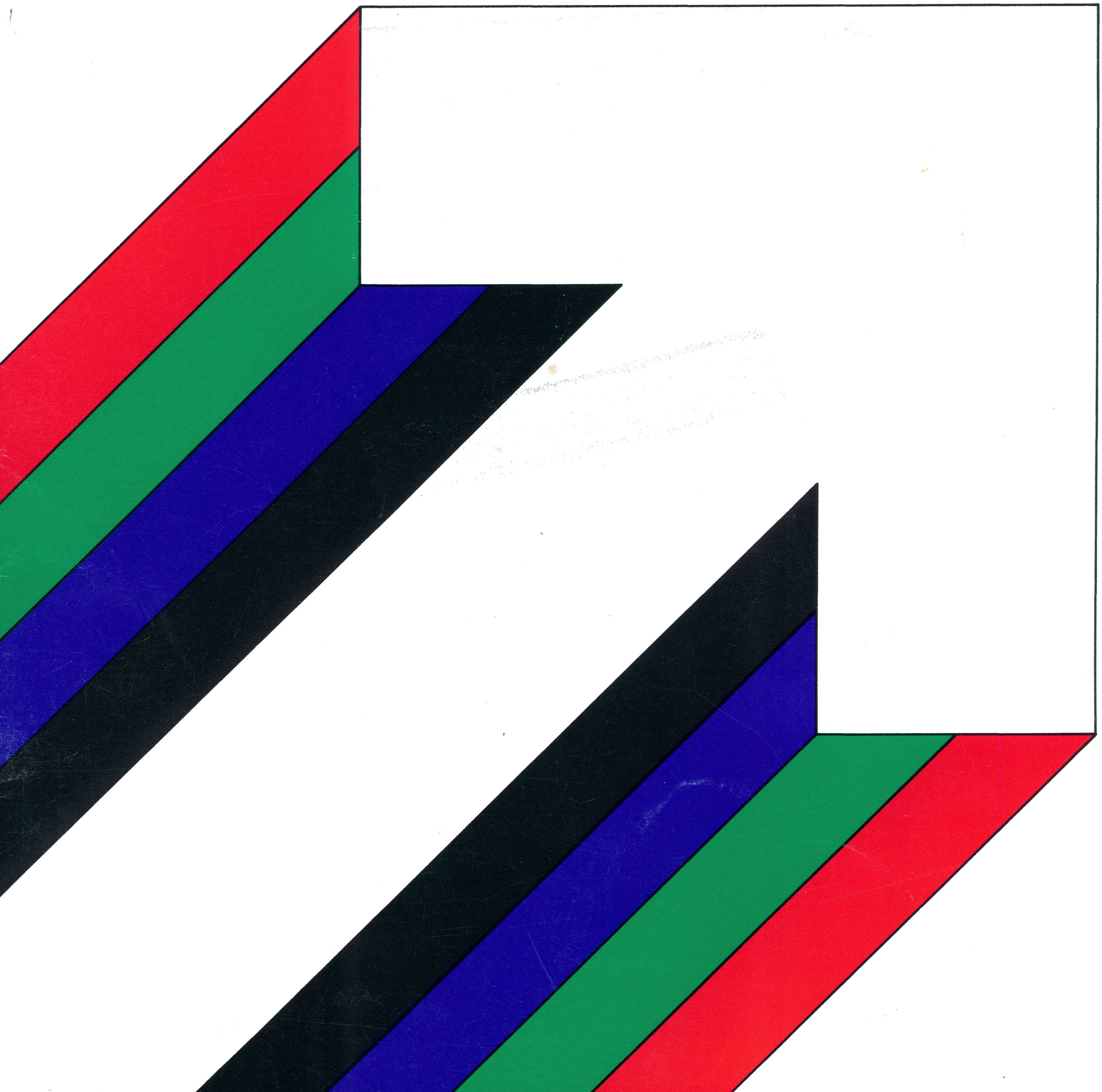
BULLETIN NO. 2

The Influence of Paper on Color Printing



WARREN

How will it print?

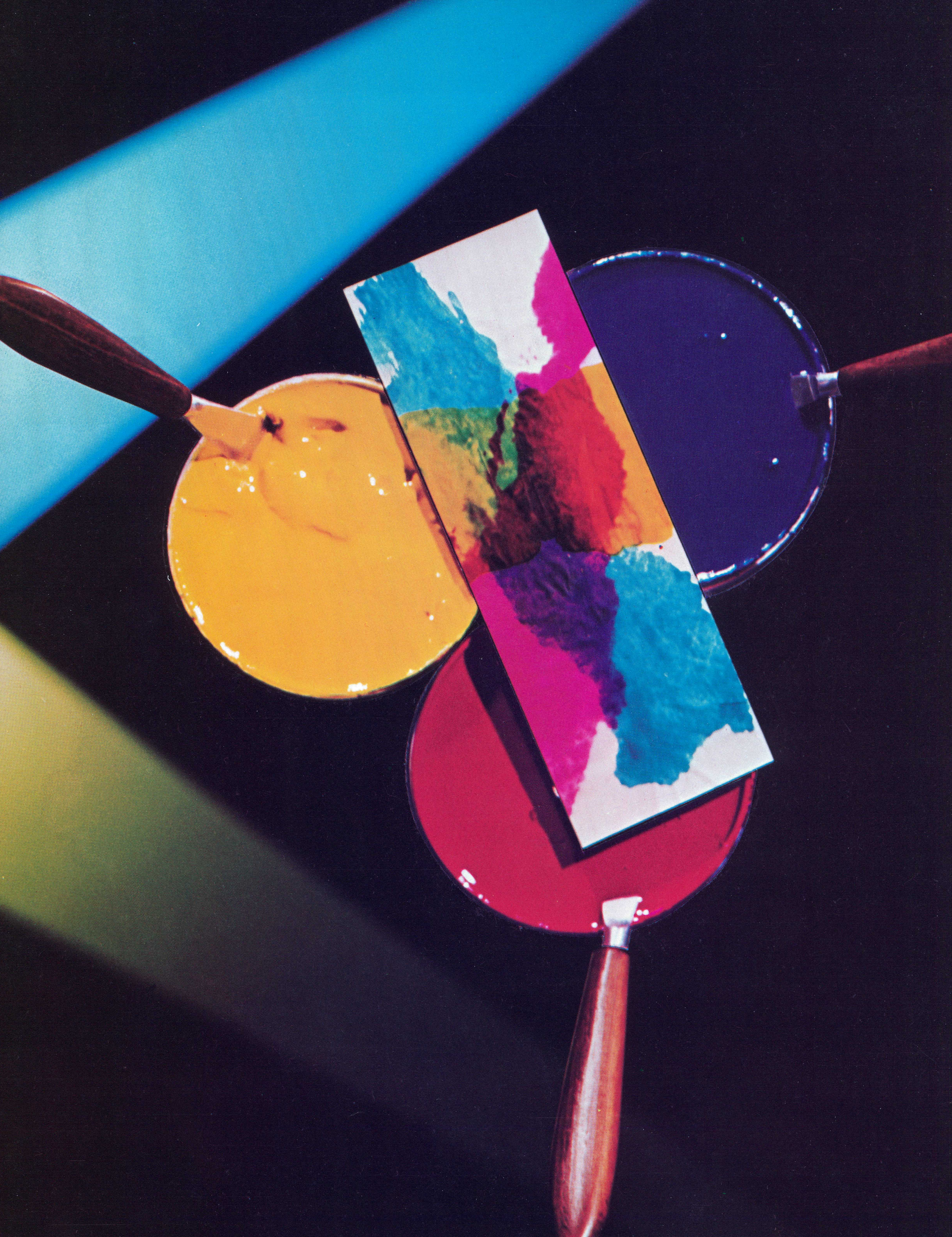
This bulletin is issued by S.D. Warren Company for the purpose of aiding the graphic communications industry in dealing with the complexities of the printing and lithographic processes. The information contained herein is a combination of the findings of scientists and the observations of experienced craftsmen. No true scientist will claim that existing knowledge is complete, and no sincere craftsman will pose as a final authority, and therefore the text of this bulletin represents merely the considered opinions of experienced and thoughtful analysts.

The Influence of Paper on Color Printing

This booklet has been written to provide a clearer understanding of color and its effects when printed on paper.

To be more specific, it has been designed to:

- Explain and demonstrate the relationship between the white light and process color.
- Explain and demonstrate the practice of process color printing.
- Explain and demonstrate the influence of paper on color printing.



What is color?
Chapter 1

Color is light. Light is a form of energy and, according to theory, travels in waves.

Light waves emanate from a source such as the sun, a light bulb, a white candle, etc. In any of these sources of light, there are many different wave lengths. Wave length is measured from crest to crest in nanometers (billionths of a meter) or in millimicrons (millionths of a millimeter). The visible spectrum range is usually considered to be between 380 millimicrons and 770 millimicrons and is part of the much larger electromagnetic spectrum.

In the seventeenth century, Sir Isaac Newton established that a beam of "colorless" light passing through a prism is refracted or bent into separate bands of colors. (Figure 1)

These are called the colors of the visible spectrum. Each color has its own wave length. When all the wave lengths are combined in suitable proportions, they produce "white" light. All individual and combinations of colors are inherent in white light. We occasionally see this spectrum in nature in the form of a rainbow.

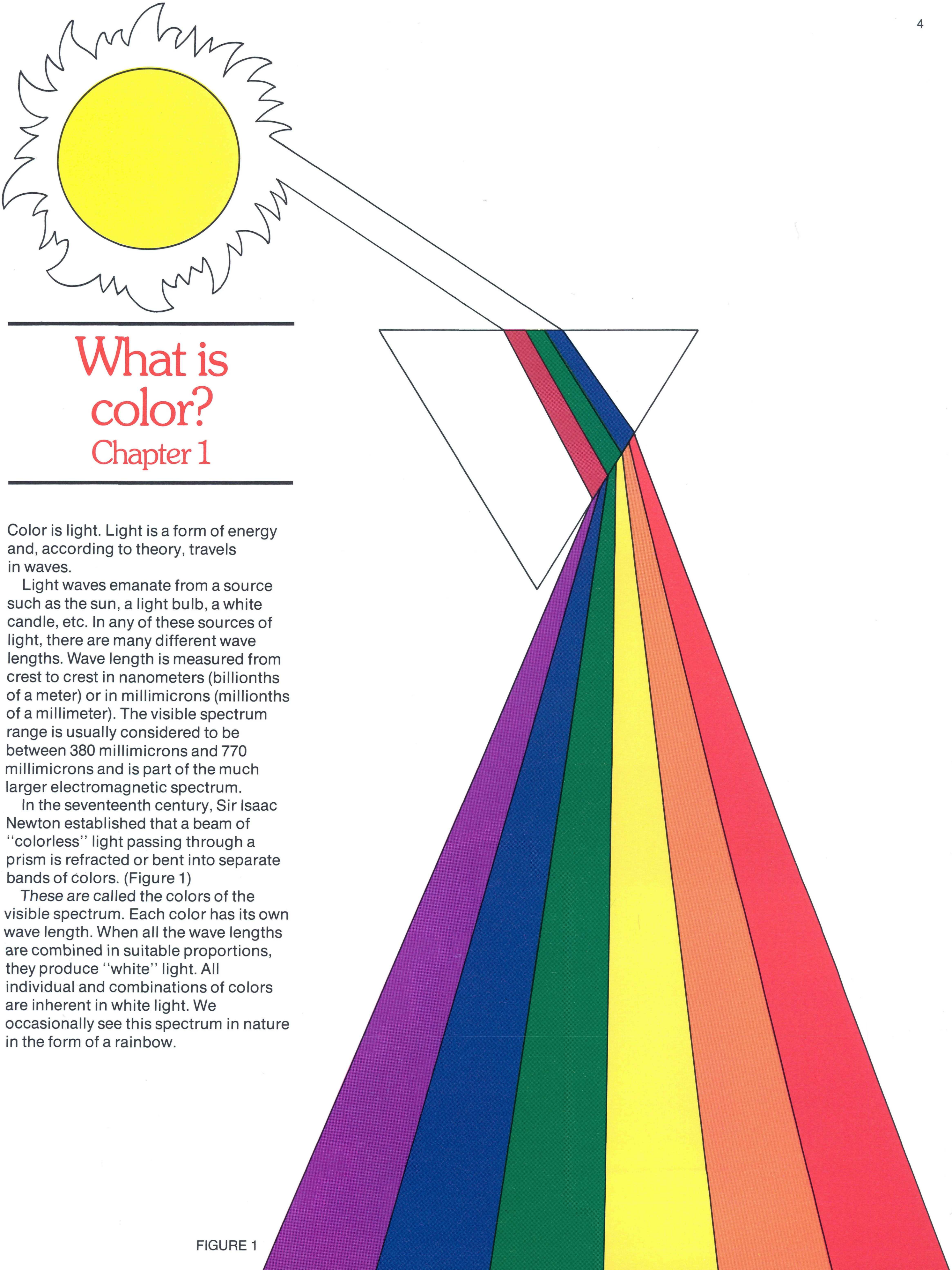


FIGURE 1

HOW WE SEE COLOR

All visible colors are contained in "white" or "colorless" light. Light energy travels in waves with each perceived color having a dominant wave length which differs from the wave length of any other perceived color.

The human eye acts as if it has "color receptors". One set of receptors is sensitive to red wave lengths of light, a second is receptive to green wave lengths, the third is sensitive to blue-violet wave lengths. When the red and green receptors are stimulated we see yellow as shown in figure 2. The various colors of the spectrum are seen depending on the strength and mixture of wave lengths which strike our receptors.

We see colorless or white light when our receptors are stimulated equally. Color then is a sensation resulting from light energy impinging on receptors in our eyes which our brain interprets as being various combinations of red, blue and green.

From the foregoing it can be seen that perception of color is totally dependent upon light. Perception depends upon the quantity of light and the quality of light available to the observer. Without any light there is no visual perception at all, let alone of color. (It doesn't take many moments in a pitch black room to prove this to ourselves, or when we see brilliant colors fade to a neutral gray and finally disappear as light diminishes from daylight to dusk to darkness.) Variation in the quality of light influences our perception of color, too. (Have you ever bought a suit that appeared to be of one shade under store lighting but different out in the street?)

FIGURE 2

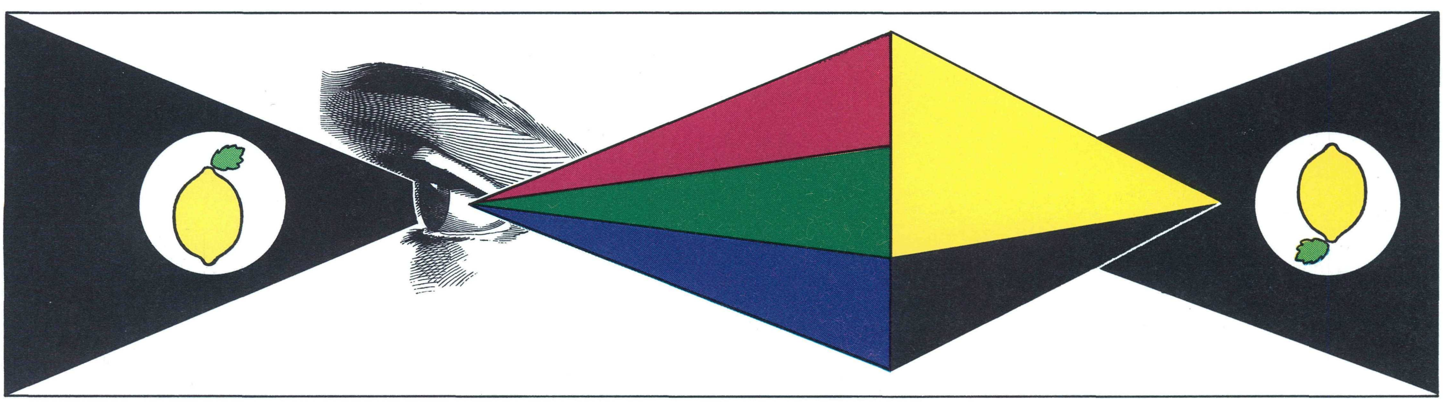
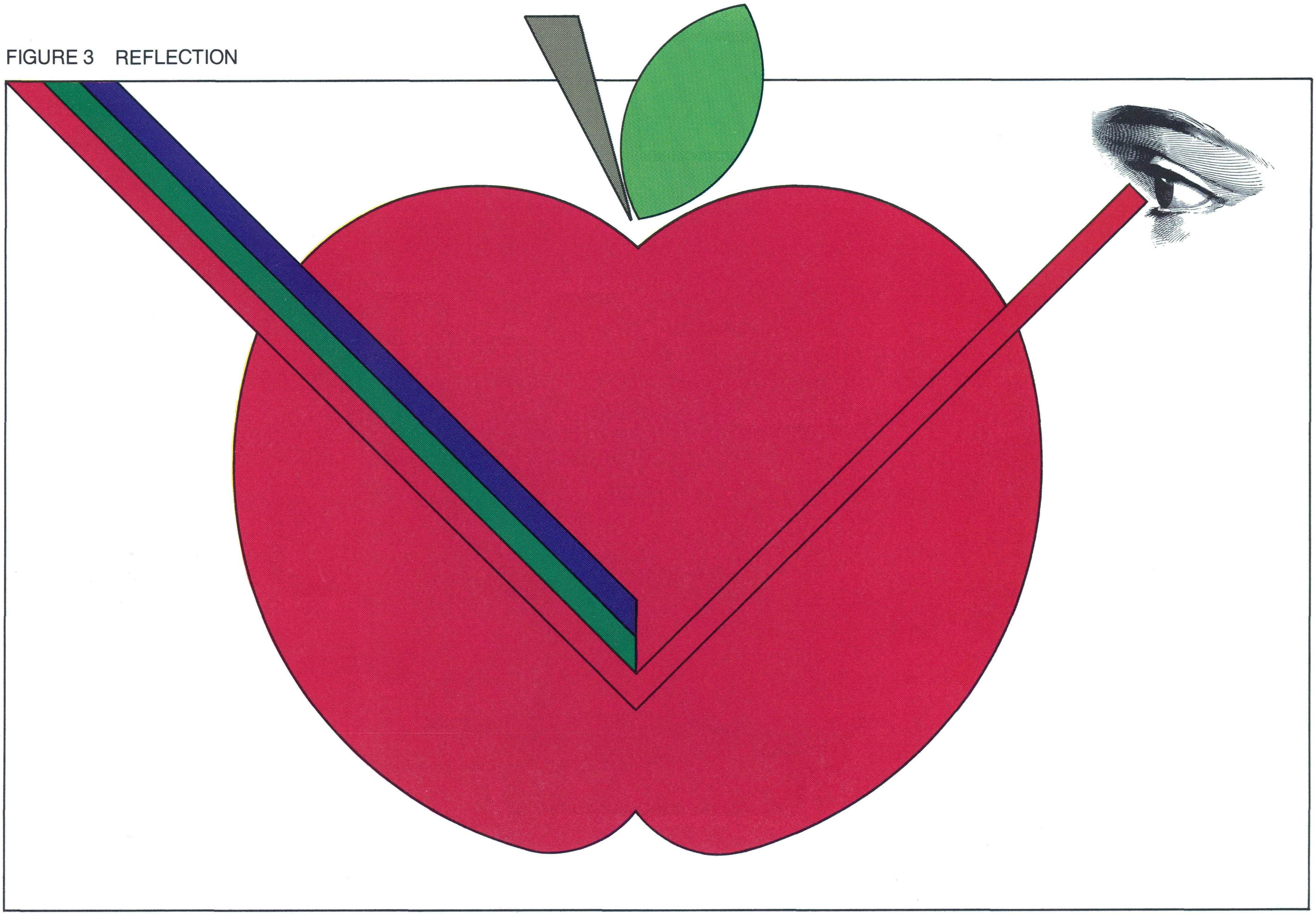


FIGURE 3 REFLECTION



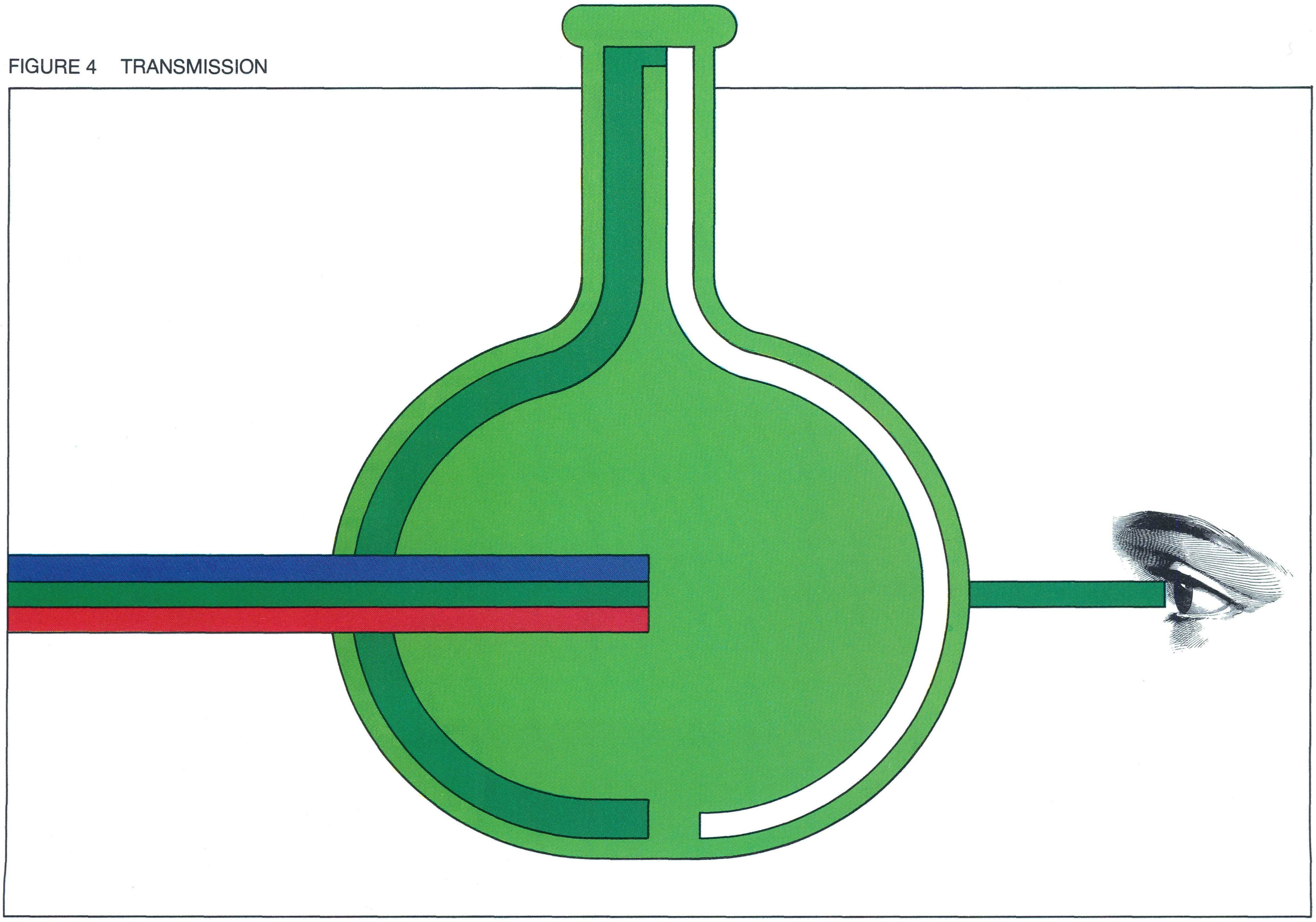
Light waves reach our eyes in a number of ways: directly (when we stare into the sun or a light bulb), or indirectly (when light waves pass through a transparent object held between the source of light and our eyes (called transmission) or when light bounces from an object to our eyes (called reflection).

The red of an apple is an illustration of color perceived by light reflection. Why do we see it as red?

The apple absorbs all wave lengths but red, which is reflected from the surface of the apple to the eye. The receptor susceptible to stimulation by this particular wave length sends a signal to the brain. The brain upon receiving the signal says— "red". (Figure 3)

In other words, an opaque substance like an apple appears to be a particular color because it reflects the wave lengths corresponding to that color and absorbs those that don't. If it reflected all wave lengths without any one wave length dominating the other, the substance would be perceived as white.

FIGURE 4 TRANSMISSION



The principle remains the same for a transparent substance, such as colored glass or film. The transparent substance absorbs some wave lengths and transmits others. The transparent object such as the green bottle is seen as green by the same principle that the apple is seen as red. All wave lengths but green are absorbed. The green wave length is transmitted rather than reflected to the eye. See Figure 4.

And that is how we see color.

PRIMARY COLORS OF LIGHT

VISIBLE SPECTRUM

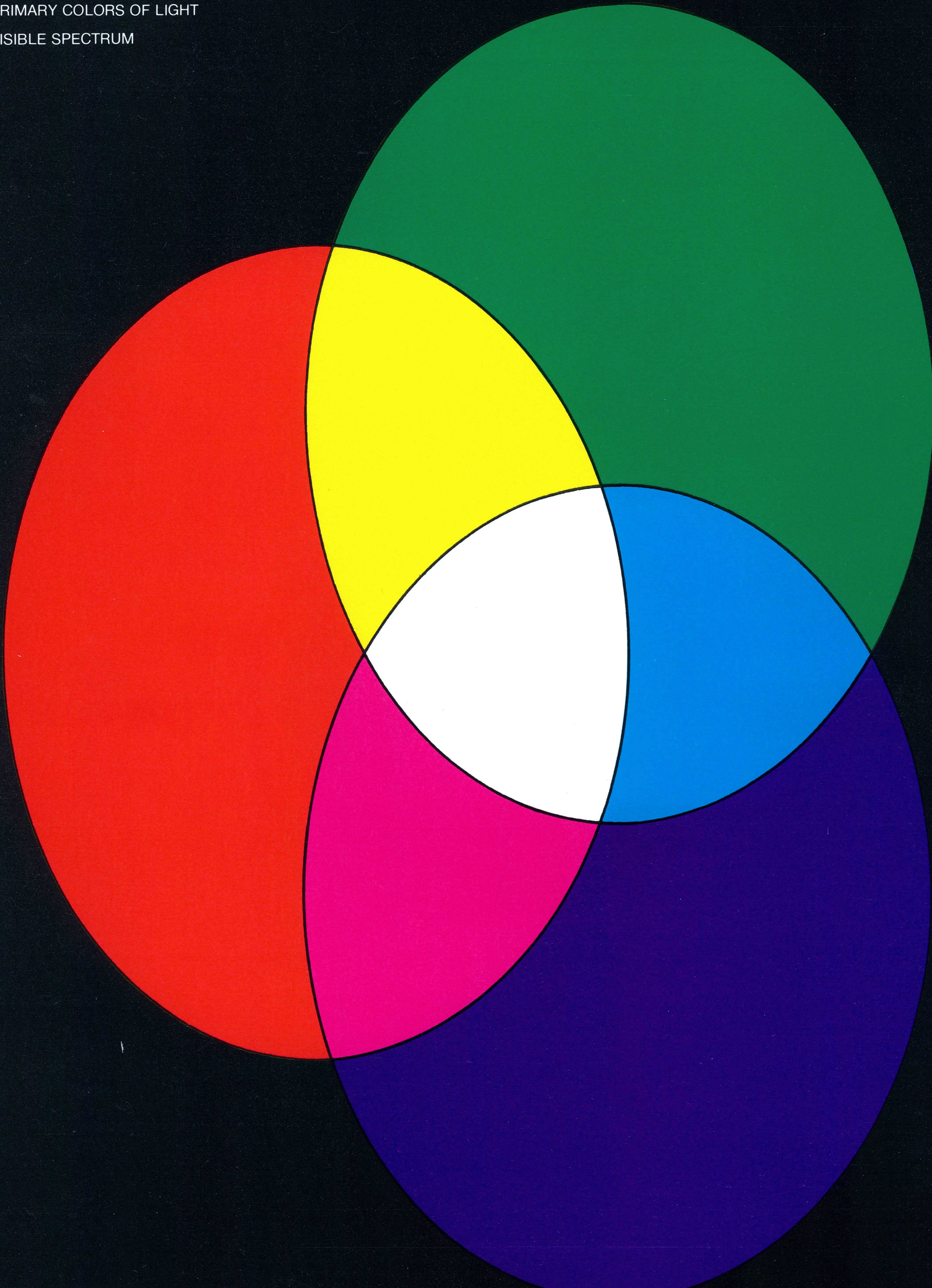


FIGURE 5

SECONDARY COLORS OF LIGHT OR PRIMARY PRINTING INK COLORS

PROCESS COLORS

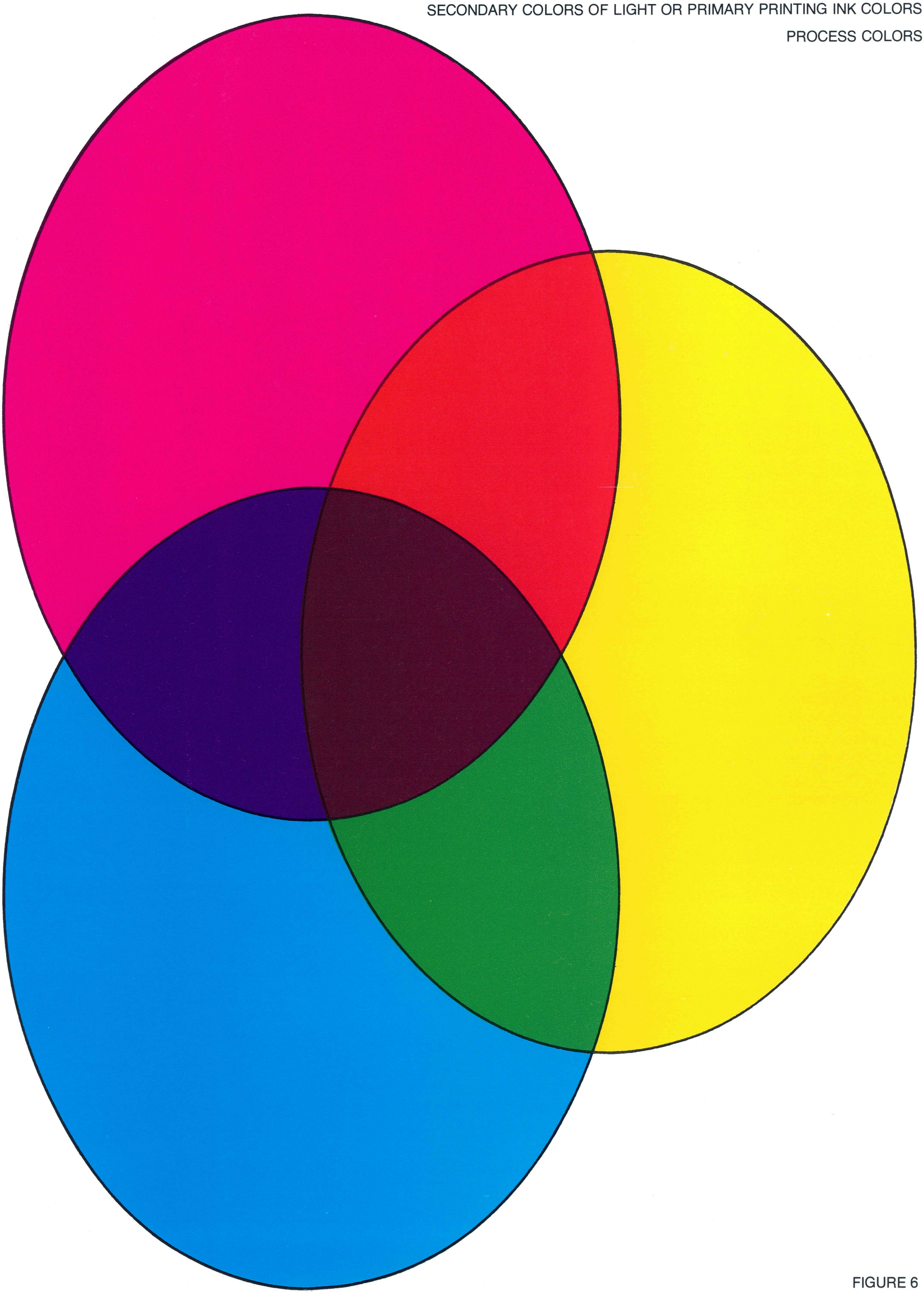


FIGURE 6

ADDITIVE AND SUBTRACTIVE COLOR

There are other aspects of light and color, and to understand them we must return to Sir Isaac's spectrum. Not all of the colors of the spectrum have "equal status".

There is a basic difference between the color behavior of light and the color behavior of the "red" apple. It is basically a difference between something that adds or subtracts. Color that results from adding light energy is called additive color. Color that results when an object subtracts light energy is called subtractive color.

A light source, such as the sun or a light bulb, is additive energy. Two separate light sources contribute more energy than one light source. (Figure 8) Yellow is perceived when a green light source adds its energy to the energy of a red light source. The result is obtained by the addition of energy of differing light wave lengths.

It can be demonstrated that three colors, red, green and blue, when suitably combined, will reproduce white or colorless light. (Figure 5) Also by combining red, green, blue in different proportions any of the other colors of the spectrum can be produced.

Thus, red, green and blue are called the primary colors of the visible spectrum. A combination of any two primaries produces an intermediate color which we call a secondary color. Red and blue produce magenta, green and blue produce cyan, and, believe it or not, green and red produce yellow. (Figure 7)

The red apple in Figure 3 subtracts energy. It has no light energy of its own, but modifies light contributed to it from a radiating source, such as the sun or a light bulb. Inks, pigments, apples, and almost anything else you can think of are perceived as a certain color because we "see" the wave lengths they reflect or transmit. We do not "see" the wave lengths that are absorbed.

It is particularly important for us to also understand the subtractive method of obtaining color, for in the graphic arts we are concerned with such light absorbing materials as pigments, films and paper surfaces. All materials that are not sources of light energy operate by the subtractive method.

As there are three additive primary colors of light (red, green and blue), which add their energies to produce all the other colors of the visible spectrum, so three subtractive colors may be selected which, in proper combination, duplicate the colors of the visible spectrum. (Figures 1, 2 and Figure 7)

These subtractive secondary colors are commonly known as cyan, magenta and yellow. Cyan contains blue and green; magenta contains red and blue. Each process printing ink, cyan, magenta and yellow, ideally transmits two-thirds of the spectrum and absorbs one-third of the spectrum, that is cyan (blue/green) absorbs red; magenta (red/blue) absorbs green; and yellow (red/green) absorbs blue. (See Figure 7)

As in Figure 9 (a) cyan has the property of transmitting blue and green and absorbing red. Yellow has the property of transmitting red and green and absorbing blue. The only color that both have in common or that both can transmit is green—hence the visual result of overlapping these two subtractive secondaries is green. In (b) we have overlapped all three subtractive secondaries, there is no one color common to all three; therefore, they in effect cancel each other out and the result is black.

(c) and (d) illustrate that subtractive secondaries are needed to make the reproduction of other colors possible by the subtractive process. In (c) we have overlapped blue and red. Each is a single color representing and transmitting only one-third of the spectrum, absorbing two-thirds. Therefore, they cancel each other out, for they in effect have nothing in common. A third color results from the overlapping of two colors that have a color in common. See (d).

We have adopted a convenient device of dividing the spectrum into thirds. Each of the subtractive secondary colors of light composes, for practical purposes, one third of the visible spectrum. Each of the subtractive primary colors represents two-thirds of the spectrum, which they must do in order to make the subtractive process work efficiently. (Figure 6)

FIGURE 7

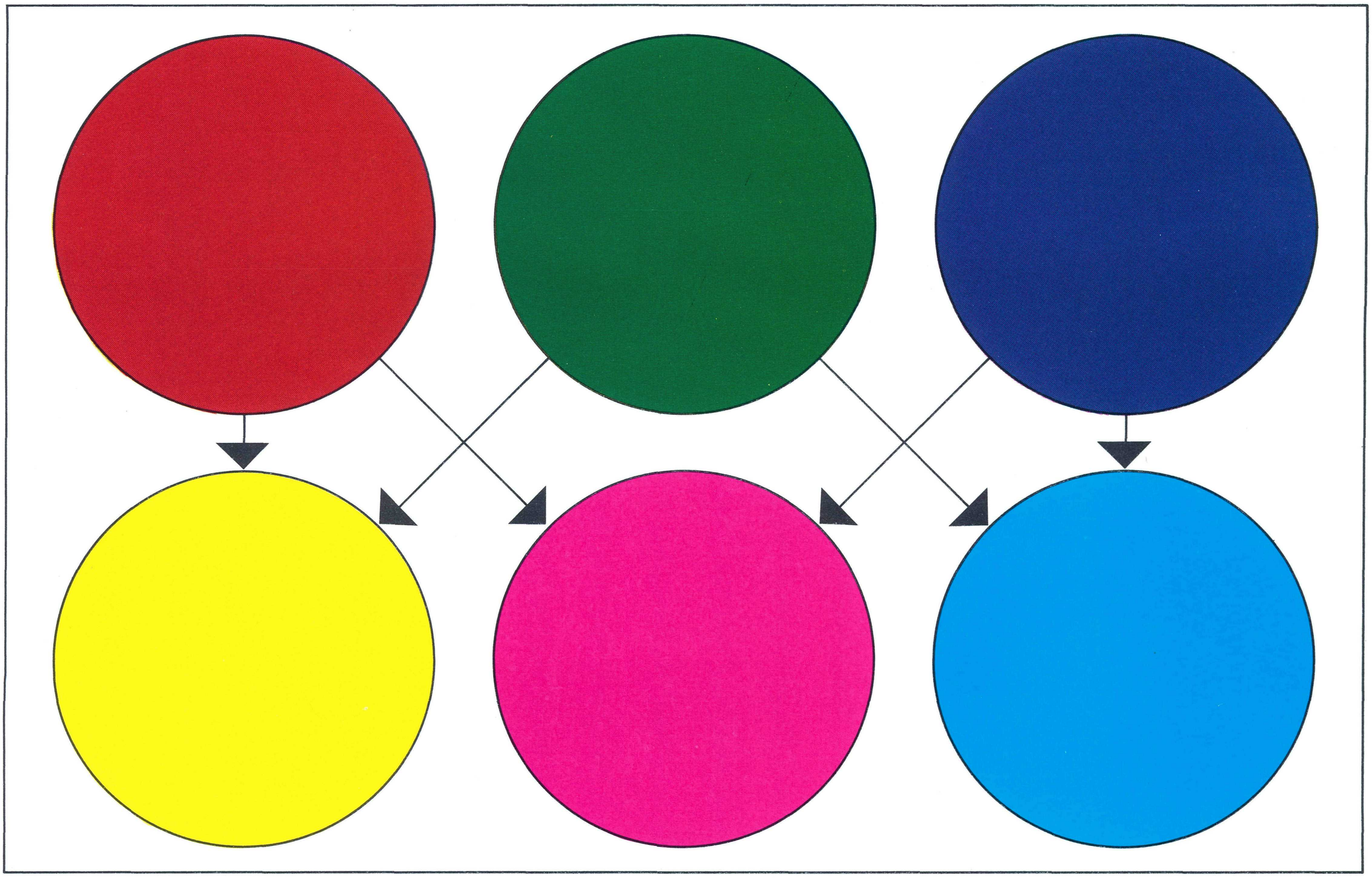


FIGURE 8

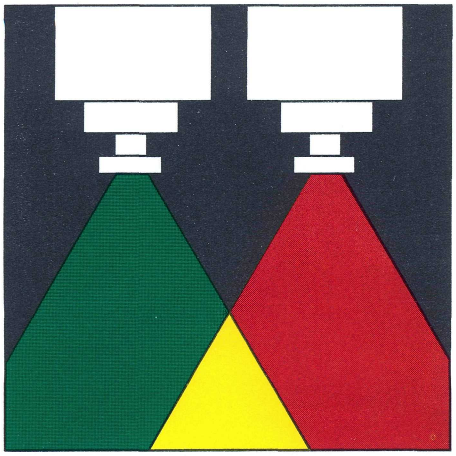
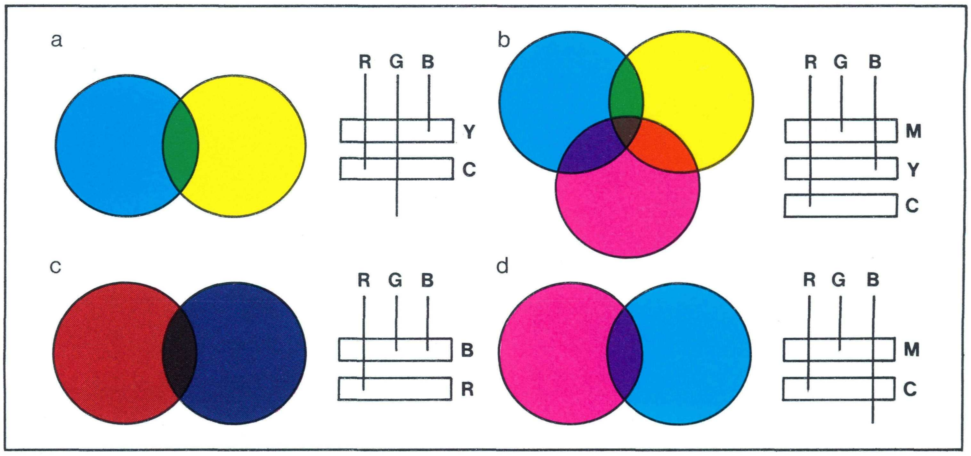


FIGURE 9



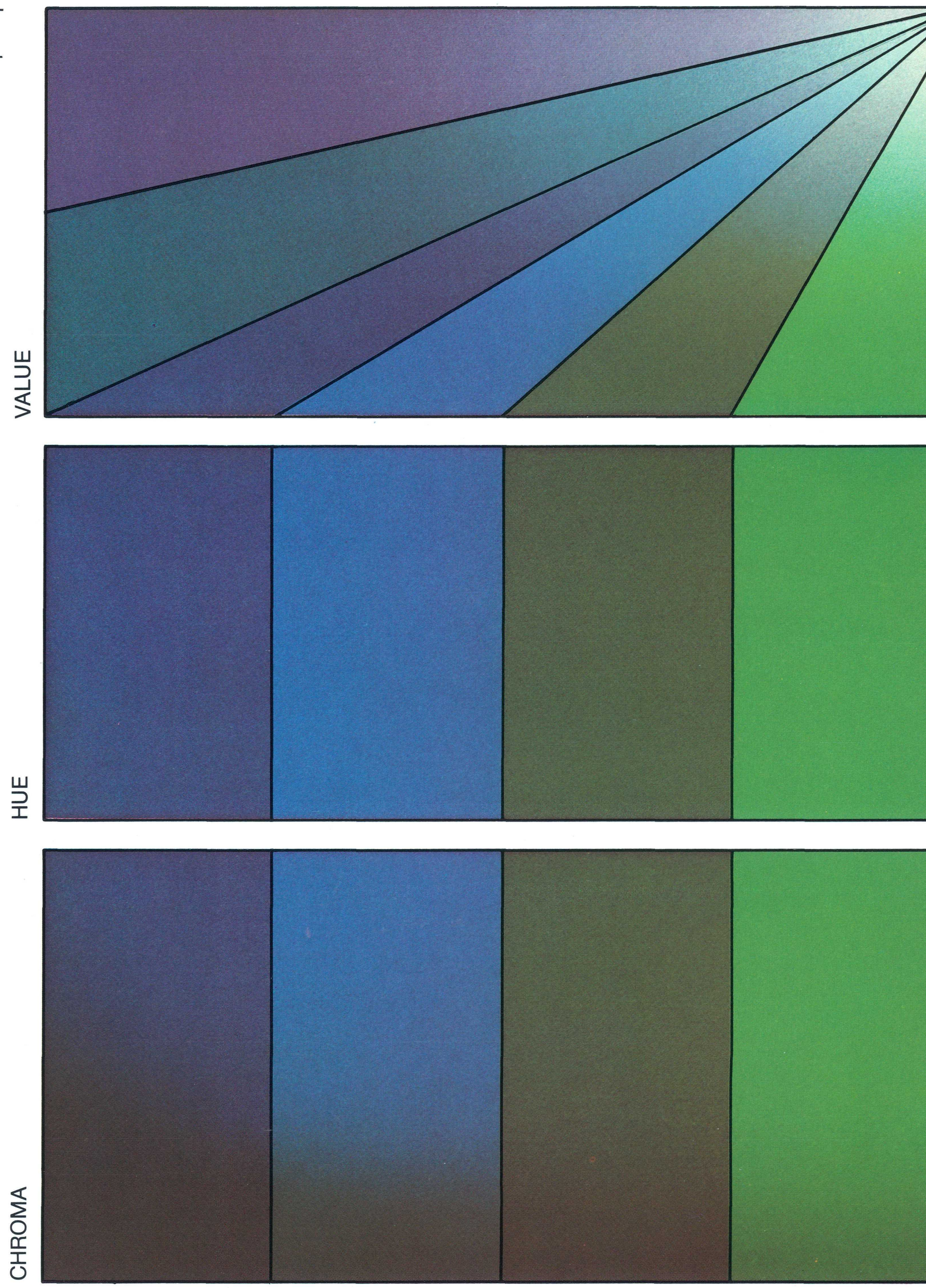
DIMENSIONS OF COLOR

Before going further, we should mention that color has three important dimensions which are:

HUE—
that characteristic of color (that we call red, green, yellow, blue and so forth). By measurement it may be assigned a dominant wave length.

VALUE—
the lightness or darkness of a color as measured against a scale running from white to black. Hence, we have light blues and dark blues, or light red, or dark greens, and so forth.

CHROMA—
is descriptive of hue purity or cleanliness, which is another way of describing intensity or saturation. Thus we might call a color "pure blue" as distinct from a "grayish blue".



Summary

1. Color is a light.
2. Light travels in waves.
3. All visible colors are inherent in white or colorless light, each perceived color having its own dominant wave length.
4. Red-blue-green are the primary colors of light and by selectively adding them, all other colors of the spectrum, as well as white light, can be produced.
5. There are light sensitive receptors in our eyes. One type responds to red wave lengths, another responds to green wave lengths, and the third to blue/violet wave lengths.
6. Additive colors are produced by combining different light waves.
7. Subtractive colors are produced when a substance, which is not itself a source of energy, subtracts light energy from an outside source.
8. The subtractive secondary colors of light absorbing materials are magenta, cyan and yellow.
9. Color has dimension. Three important dimensions are:
   HUE—or dominant wave length (red, blue, pink, etc.)
   VALUE—(lightness)
   CHROMA—(saturation, intensity, purity)

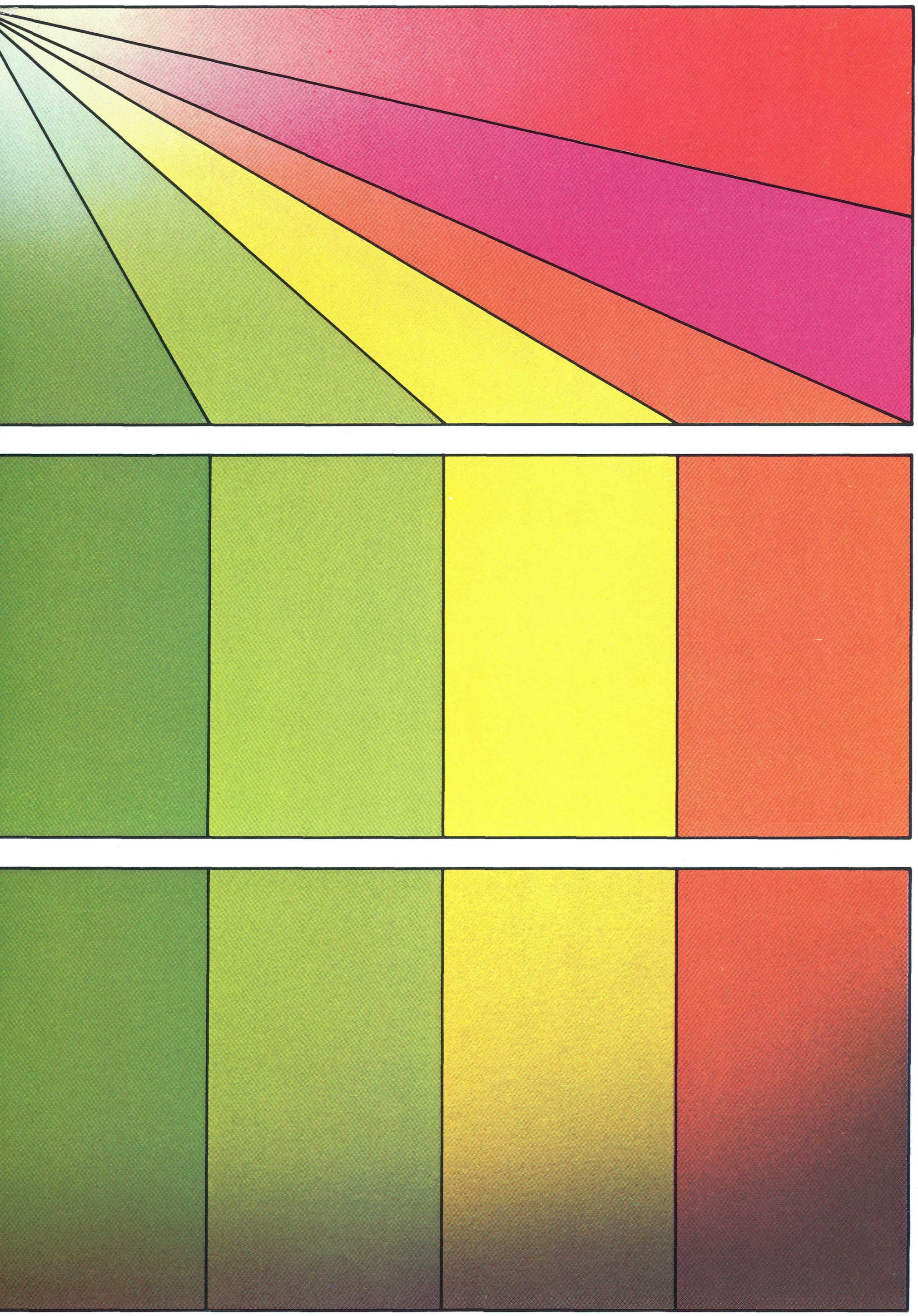


FIGURE 10

What things influence the appearance of color?

Chapter 2

Environmental changes in which color is observed influences perception of color.

To be more specific the following conditions influence our perception of color:

The color quality of light under which colors are observed.

The proximity of other colors to the color or colors we are observing. Or changes in the value (lightness/ darkness) of the background against which colors are observed.

The surface texture underlying the color we are observing.

Let's look at each of these three conditions in order:

THE INFLUENCE OF THE COLOR QUALITY OF LIGHT UNDER WHICH OTHER OBJECTS ARE OBSERVED.

We see colors under varying light conditions. The color "makeup" of daylight differs, for example, from the color quality of an incandescent light bulb. This simply means that though both are seemingly white, there are certain wave lengths in each source that are stronger than others. North light at noon, for example, is energy rich in the blue end of the spectrum, while incandescent lighting is characteristically rich in the yellow-red end of the spectrum. Fluorescent lights may simulate most any energy distribution. Candlelight is distinctly yellow.

A white object viewed under each of these sources exhibits the characteristic (though slight) color of the source. An observer may or may not be conscious of this—depending on the light source. (A white object, remember, reflects the same quality of light that strikes it.)

The color perception of all materials that selectively absorb some wave lengths from light and reflect or transmit others is influenced by the composition of the light that strikes them. For example, flesh tones which reflect red light must have sufficient red wave lengths in the light source to appear natural. This photograph was taken under illumination made up of equal amounts of red, green and blue wave lengths. (Figure 11A)

This photograph was taken under illumination with a deficiency of red (or a predominance of blue) which resulted in a dead and grayish flesh tone because the needed red wave lengths were not available. (Figure 11B)

FIGURE 11A

FIGURE 11B

FIGURE 12

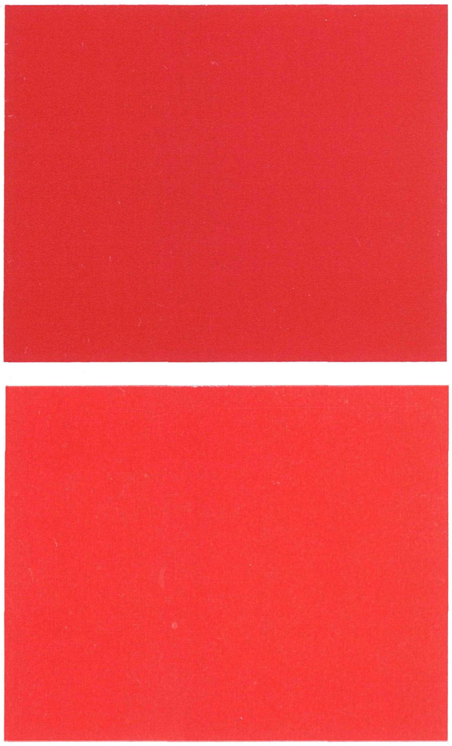
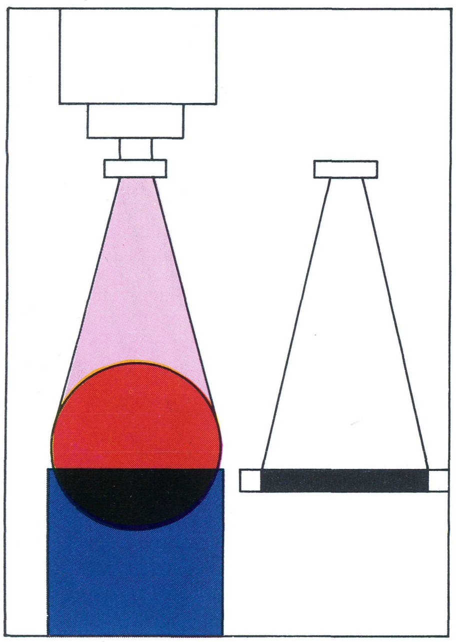


FIGURE 13



Because light sources vary, color matching and comparing is difficult unless observations are made under the same light source.

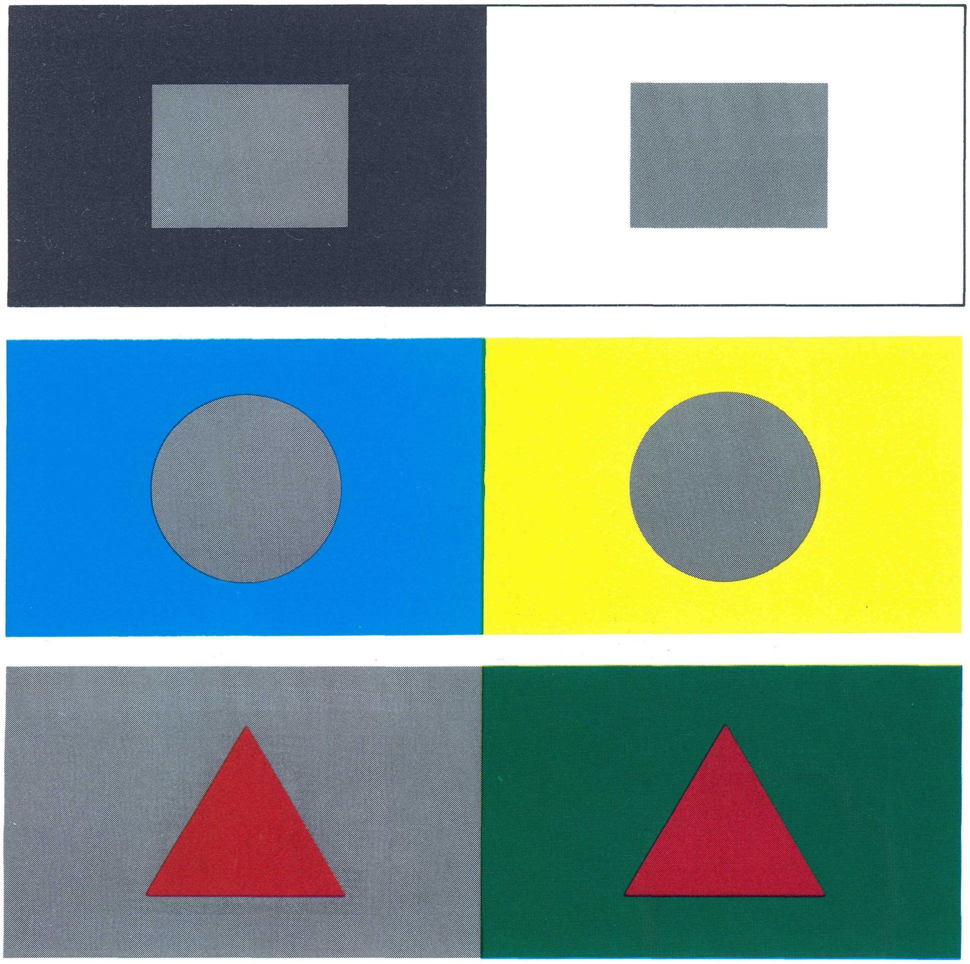
This is a metameric color match. Under one light source the colors will appear to match; under another they will obviously differ. Under fluorescent lights of a bluish white; under fluorescent lights of a pinkish white; under incandescent light, which is used in most home lighting; and under daylight, these colors will change in their relative appearance. Colors which are not made from a single pigment or dye, but are based on mixtures of colors, can be mixed to match under one set of conditions and may not match under other conditions. Take this sample to the window and see. Inks are normally matched under daylight conditions. (Figure 12)

It is possible to demonstrate dramatically the influence that a light source has on color observation. If a blue object were viewed under pure red light, the object would appear black. The subtractive color phenomenon, of course, explains this. (Figure 13)

In addition to the spectral quality (color makeup) of the light source, the strength or brightness of the light source influences color perception. We may observe the effect of varying brightness when daylight turns to darkness and the greens and reds of nature become darker and duller until eventually their hues are no longer identifiable. (Figure 14)

FIGURE 14

FIGURE 15



THE INFLUENCE OF THE PROXIMITY OF COLORS TO THE COLORS WE ARE OBSERVING AND THE INFLUENCE OF BACKGROUND BRIGHTNESS.

Artists and designers historically have been interested in the influence of one color on the perception of another, for use and understanding of color relationships is as important an aesthetic and psychological tool to them as knowledge of form, balance and composition. There are many interesting and surprising examples of the interaction of color, some of which we see here. (Figure 15)

Dark colors on light colors look darker than dark colors on dark colors.

Complementary colors, when mixed equally, gray or weaken each other. (Figure 16A)

Complementary colors, when side by side, reinforce each other. (Figure 16B)

There is another aspect of one color influencing another. The color of transparent objects may be subtly or dramatically influenced by the color of the background against which they are viewed. This color may be influenced by the quality of the light source—as in viewing a photographic transparency—or by the quality of reflected light—as when something transparent is viewed against an opaque background, such as a sheet of paper. Also a given color will alter in appearance as the value (brightness) of the background changes such as in Figure 14.

FIGURE 16A

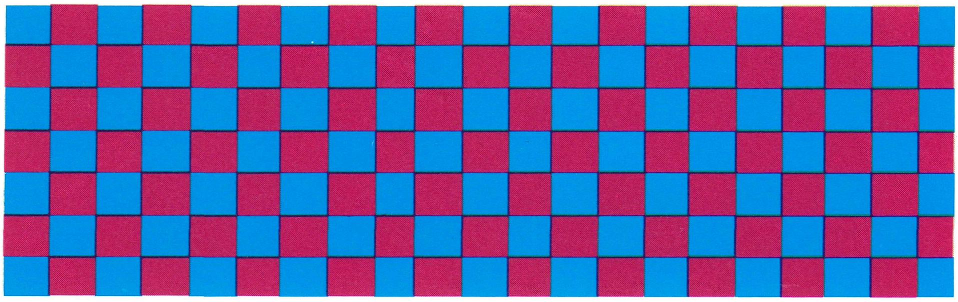
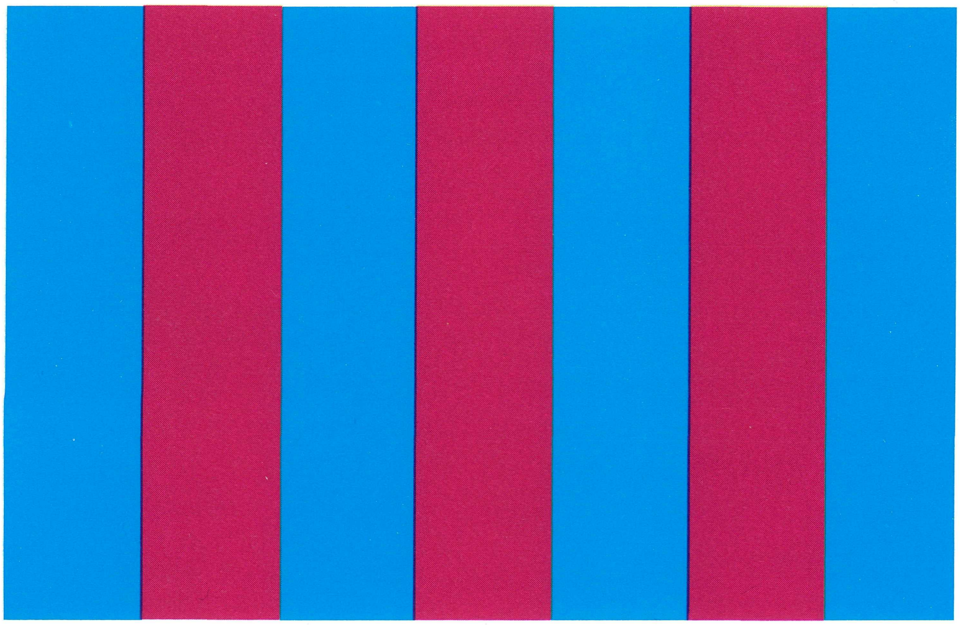


FIGURE 16B



THE INFLUENCE OF TEXTURE ON PERCEPTION OF COLOR.

The appearance of a given hue varies as the surface texture of the colored object or material varies. An ink printed on a smooth, glossy surface appears purer and more brilliant in hue than the same ink on a rough surface where it appears to be grayed, washed out, or less pure. (The rough surface scatters white light as bits of broken glass do, adding white light to the printed area, and we perceive the color to be "diluted".)

Rough surfaces provide randomly placed light reflecting facets. In effect this uncontrolled addition of white light raises the value and decreases the saturation or chroma of the print. For additional information, see the chapter on paper. (Figures 20 & 21)

Summary

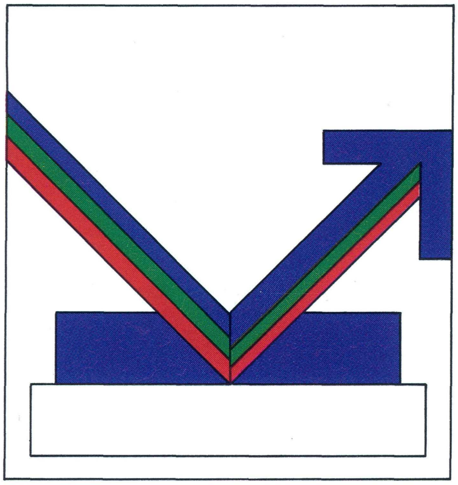
Our perception of color is influenced by:

1. The quality of light under which a color is observed.
2. The relationship of the observed color to other colors.
3. The color and brightness of the background.
4. The texture of the colored surface.

How do printing inks work?

Chapter 3

FIGURE 17



Inks may be either opaque or transparent. Although there are many uses for both, the bulk of printing and all reproduction of colored pictorial material, such as art work or photography by process printing, require transparent inks. Such reproduction utilizes the three transparent subtractive secondary colors (plus black generally) to reproduce all the colors of the original.

Reproduction by process printing requires use of the subtractive secondary colors (and often black to deepen shadow areas or to increase contrast). The colors are yellow, magenta and cyan. When they are combined, you see several colors—but it is called a three color reproduction. (See Figure 2)

A colored transparent ink film modifies light by subtracting from the light source certain wave lengths and transmitting others. Just as the green bottle subtracts red and blue and transmits green as in Figure 4.

Opaque inks, like the apple, reflect light; no light passes through them. Transparent inks, unlike the red apple, allow light to pass through them. (See Figure 3)

But transparent inks obviously are not suspended in mid-air between a light source and the eye as a piece of colored glass might be. Rather, they lie flat against a sheet of paper. The paper then becomes the reflecting light source for the ink placed on it. (See Figure 17)

When transparent ink films are overlapped, as in process printing, they produce intermediate colors because each film layer allows light to pass through it. On the other hand, overlapped opaque colors reflect light, they do not transmit or pass light and so do not produce intermediate colors when they overlap. Silk screen printing lays down thick opaque films of ink. Overprinting completely hides the color underneath. (See Figure 18)

Theoretically, perfect process ink subtractive secondary colors, capable of reproducing most of the other colors of the spectrum, are:

Cyan—(absorbs all red and transmits blue/green)

Magenta—(absorbs all green and transmits blue/red)

Yellow—(absorbs all blue and transmits green/red)

Unfortunately, there are no perfect process inks, and ink formulations are varied to best satisfy particular requirements.

Additional correction and adjustment in preparatory photographic and platemaking steps prior to printing must be made to compensate for ink limitations in order to obtain the most accurate results.

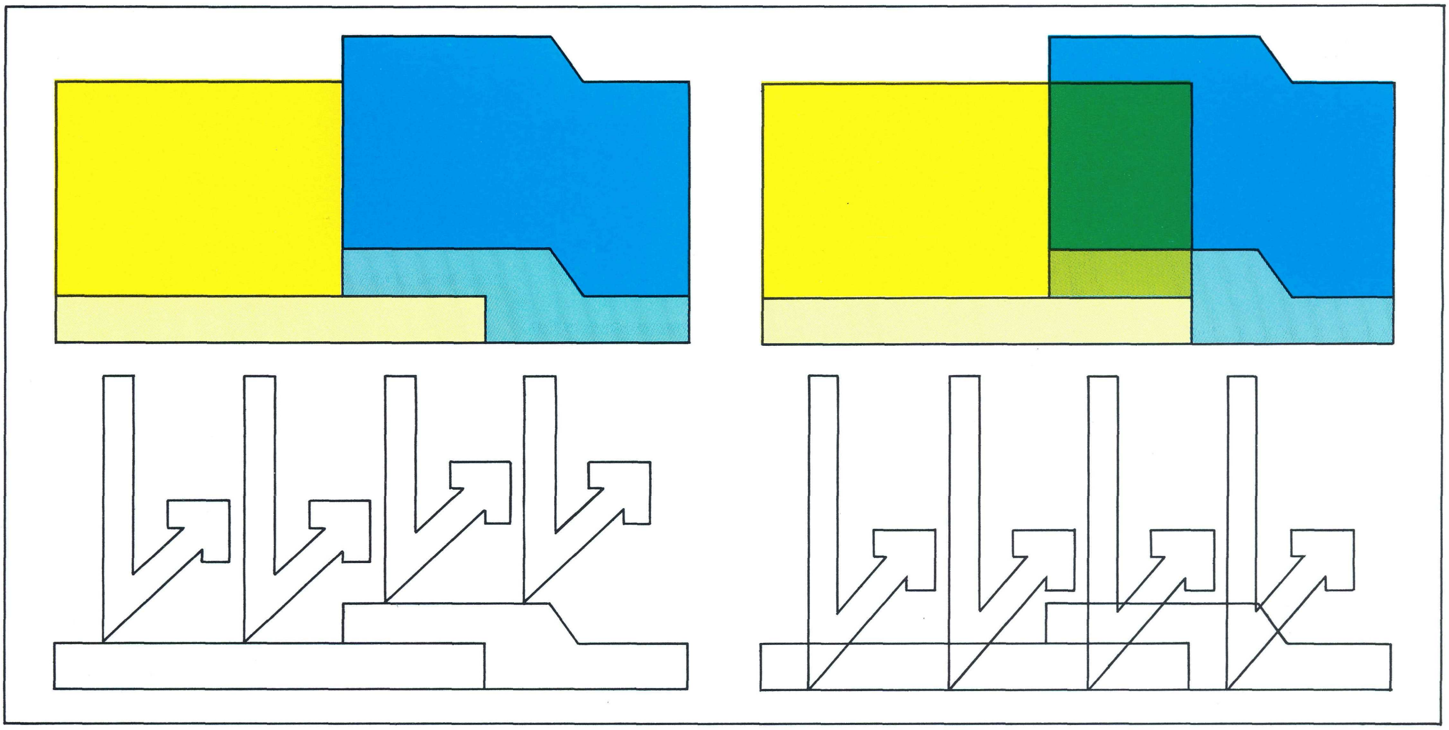
Beyond this, the three process printing inks do not have the same reproductive range as some art mediums, such as oil base paints; nor can they reproduce all the subtle hue and value variations found in some colored originals.

This is why some reproductions are often less brilliant than the originals.

The introduction of the Halftone Screen compresses the tonal range or range of values available in a printed reproduction, because the minute unprinted areas of the white paper reflect white light and dilute the print. Addition of white light raises the value of color and decreases its saturation or purity.

In spite of the limitations of the inks, and other factors such as plates, blankets and the halftone screen, color reproductions can be amazingly accurate.

FIGURE 18



Summary

1. Inks can be either transparent or opaque.
2. Transparent inks work by the subtractive process just as colored glass or film.
3. Process printing utilizes three transparent subtractive secondary colors: cyan, magenta, yellow and black is used for detail.
4. Paper is the reflective light source for transparent inks.

The Influence of Paper on Color Printing
Chapter 4

FIGURE 19A

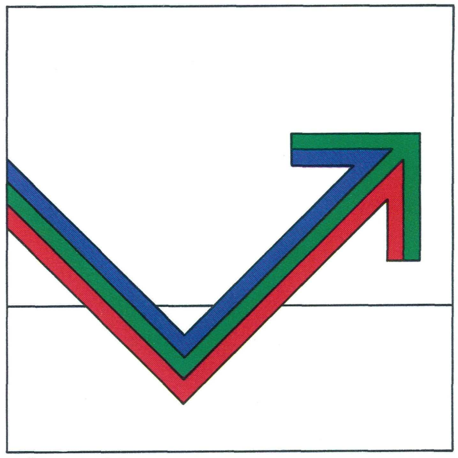
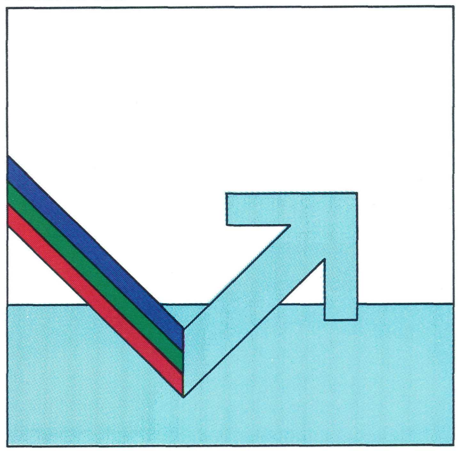


FIGURE 19B



THE INFLUENCE OF PAPER WHITENESS AND BRIGHTNESS

The immediate source of illumination for a transparent ink film is the sheet of paper on which it is printed. This is reflected illumination.

A sheet of paper has the property of absorbing some wave lengths and reflecting others. If it reflects all wave lengths equally, which means that it does not alter the quality of the light, it is a neutral or balanced white sheet of paper. (Figure 19A)

If it absorbs more of some wave lengths than the others, it will be tinted. It is an unbalanced paper. For example, if it absorbs more red and green wave lengths than it does blue wave lengths, it will be tinted blue. (Figure 19B)

If it absorbs all the wave lengths of white light it will be black paper. (Figure 19C) A neutral gray sheet of paper is simply one that absorbs a good part of the quantity, without altering the quality, of light that strikes it. You might say that a neutral gray paper is a balanced white paper at low brightness. Just as natural colors become duller, less brilliant during the onset of darkness, so ink colors become duller, and less brilliant as the brightness of a sheet of paper decreases. The unprinted area of a sheet of paper is the brightest portion of the overall

FIGURE 19C

FIGURE 19D

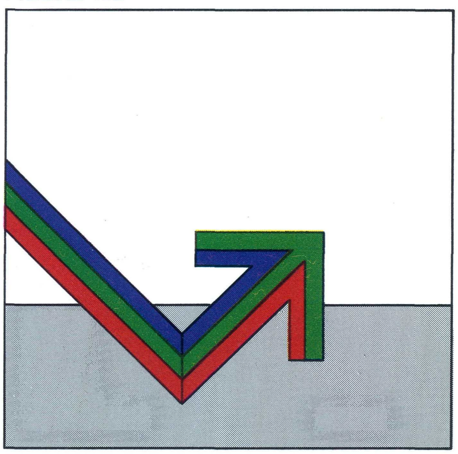


FIGURE 19E

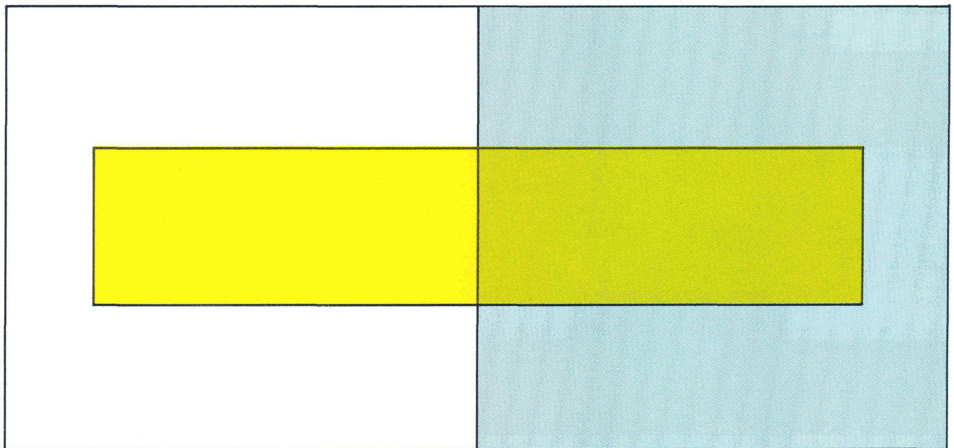
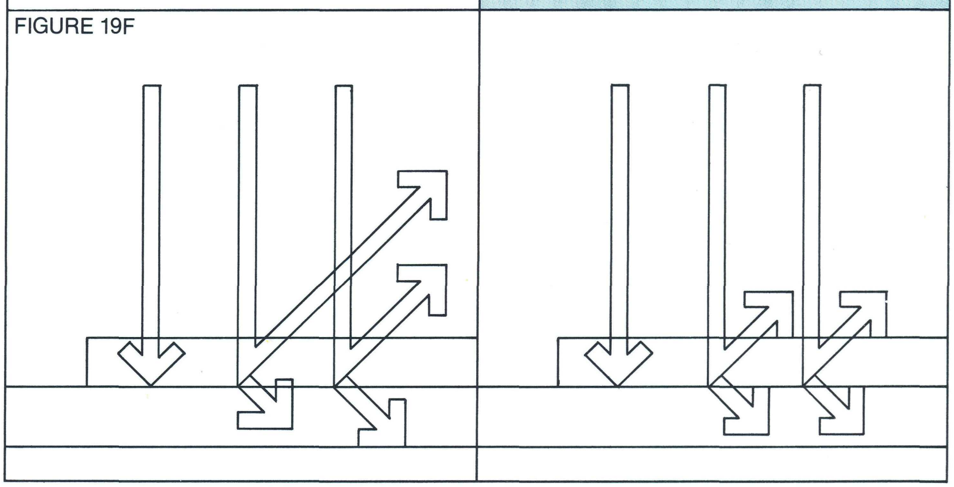


FIGURE 19F

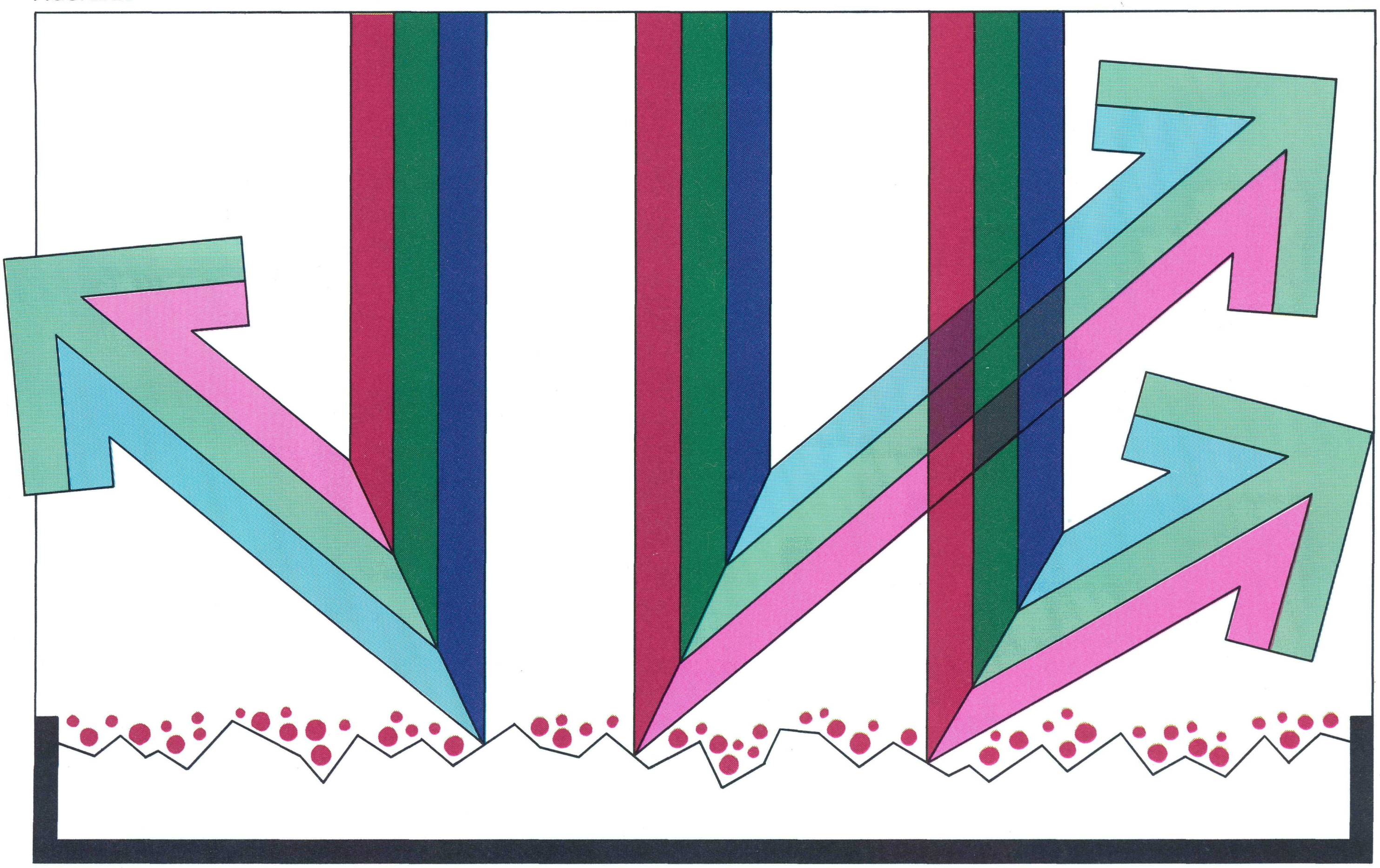


printed page. The printed areas are less bright than the non-printed areas because they have absorbed some of the light. If a printer starts with a paper of low brightness the print will be correspondingly low in brightness. (Figure 19D) The unprinted areas of a tinted paper add their characteristic color to the light reflected from the print to the eye, so that additional distortion is incurred.

Bluish papers absorb more red and green light than neutral white paper. Perception of yellow depends on green and red light. If some of this kind of light is absorbed by the paper, the yellow result is reduced in lightness or intensity, i.e., it is grayed. Many blue appearing papers also reflect proportionately more green than red, which means the yellow result is "greenish." In either case, the blue wave lengths are absorbed by the yellow ink film, hence the "graying effect." Therefore, the most accurate color reproduction is obtained on papers that reflect the light that strikes them without changing its quality. (Figure 19E)

In addition, the most brilliant color reproductions are obtained on papers with high, balanced reflectance. (Figure 19F)

FIGURE 20



THE CHARACTERISTICS AND ABSORBTIVITY OF THE PAPER SURFACE.

Besides whiteness and brightness, the degree of smoothness of the printing surface influences the appearance of ink placed on it.

A rough fibrous paper surface is composed of a multitude of non-uniform reflecting surfaces. When light strikes them, they scatter it randomly and, thus, adulterate the print with white light.

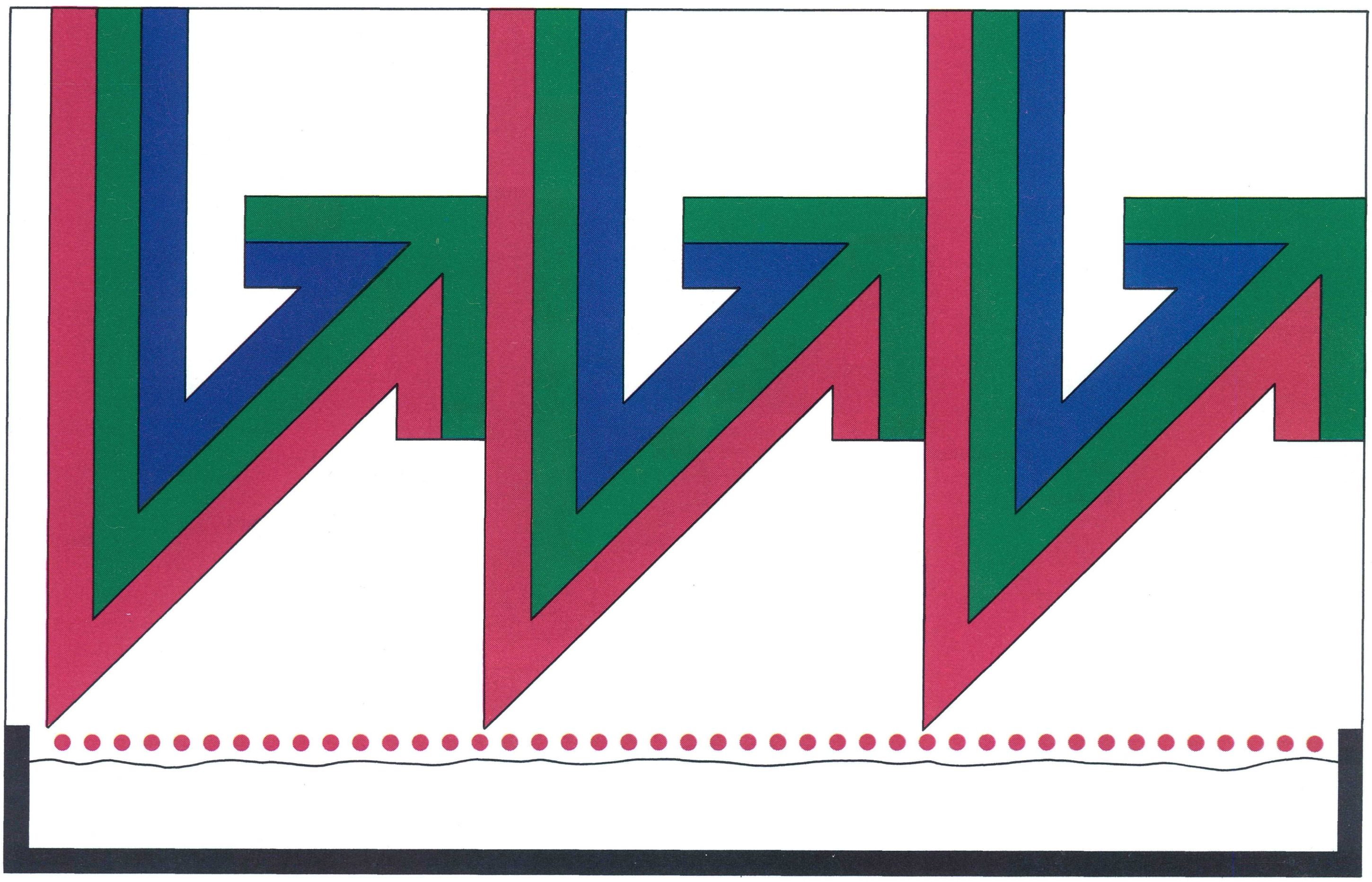
A black solid or halftone for example, is grayed because of this addition of uncontrolled and unwanted white light. A colored solid or halftone is not only grayed but also tends to change its hue.

Smooth coated surfaces with fibers buried under layers of pigment minimize light interference by allowing uniform directional reflection of light.

As a rough surface contributes to color degradation, so does an excessively absorbent- or "open"-surface. An open surface may absorb the ink vehicle and pigment, but leave dull pigment particles on the surface. (Figure 20)

A surface with good ink holdup—a "tight" surface—retains both vehicle and pigment on the surface with the pigment "buried" in the glossy vehicle.

FIGURE 21



Only enough vehicle penetrates the surface to provide good bond of ink to paper. Ink gloss contributes to purity of printed ink color. Paper smoothness contributes to ink gloss. (Figure 21)

Accurate glossy color results may be obtained on some dull coated and embossed coated papers. Even though the papers are not glossy their surfaces are so refined that—even over the surfaces of the relatively large hills and valleys of embossed finishes—a gloss layer of ink may be supported. Sufficient vehicle is supported as a smooth film to maintain the color purity of the pigments immersed in it.

Summary

1. Paper is the light source for transparent inks printed on it.
2. Transparent inks give best results when printed.
3. Papers should provide balanced high-light reflectance through the ink film.
4. And these papers should have smooth, coated surfaces which support a thin, glossy layer of ink.

Warren Paper Merchants

ALABAMA	
Birmingham	Sloan Paper Co.
Mobile	Strickland Paper Co.
	Unijax, Inc.
Montgomery	Weaver Paper Co.
ALASKA	
Anchorage	Zellerbach Paper Co.
ARIZONA	
Phoenix	Zellerbach Paper Co.
ARKANSAS	
Little Rock	Western Paper Co.
CALIFORNIA	
Fresno	Zellerbach Paper Co.
Los Angeles	Zellerbach Paper Co.
Sacramento	Zellerbach Paper Co.
San Diego	Zellerbach Paper Co.
San Francisco	Zellerbach Paper Co.
COLORADO	
Colorado Springs	Dixon Paper Co.
Denver	Carpenter Paper Co.
	Dixon Paper Co.
	Zellerbach Paper Co.
Grand Junction	Dixon Paper Co.
Pueblo	Dixon Paper Co.
CONNECTICUT	
Hartford	Carter Rice Storrs & Bement
	Lindenmeyr Paper Corp.
New Haven	Carter Rice Storrs & Bement
DISTRICT OF COLUMBIA	
Washington	Stanford Paper Co.
	Virginia Paper Co.
FLORIDA	
Jacksonville	Virginia Paper Co.
Miami	Palmer Paper Co.
	Virginia Paper Co.
Orlando	Palmer Paper Co.
	Virginia Paper Co.
Tampa	Palmer Paper Co.
	Virginia Paper Co.
GEORGIA	
Atlanta	Sloan Paper Co.
	Virginia Paper Co.
Columbus	Sloan Paper Co.
HAWAII	
Honolulu	HOPACO
	Zellerbach Paper Co.
IDAHO	
Boise	Dixon Paper Co.
	Zellerbach Paper Co.

ILLINOIS	
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	Chicago Paper Co.
	Hobart-McIntosh Paper Co.
	La Salle Messinger Paper Co.
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Peoria	Tobey Peoria Paper Co.
Rock Island	Leslie Paper
INDIANA	
Fort Wayne	Taylor-Martin Paper Co., Inc.
Indianapolis	Crescent Paper Co.
	C.P. Lesh Paper Co.
South Bend	C.P. Lesh Paper Co.
IOWA	
Cedar Rapids	Midwestern Paper Co.
Des Moines	Midwestern Paper Co.
KANSAS	
Wichita	Western Paper Co.
KENTUCKY	
Lexington	Southern Paper Co.
Louisville	Louisville/Southeastern Paper Co.
LOUISIANA	
Baton Rouge	Consolidated Marketing, Inc.
Lafayette	Consolidated Marketing, Inc.
New Orleans	Consolidated Marketing, Inc.
	Palmer Paper Co.
Shreveport	Consolidated Marketing, Inc.
	Western Paper Co.
MAINE	
Portland	C.M. Rice Paper Co.
	C.H. Robinson Co.
MARYLAND	
Baltimore	Baltimore-Warner Paper Co., Inc.
	The Barton, Duer & Koch Paper Co.
Columbia	Wilcox Walter Furlong Paper Co.
MASSACHUSETTS	
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	The Century Paper Co., Inc.
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Springfield	Carter Rice Storrs & Bement
Worcester	Carter Rice Storrs & Bement

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Grand Rapids	Carpenter Paper Co.
	Quimby-Walstrom Paper Co.
Lansing	Copco-Dudley Papers
Saginaw	Copco-Dudley Papers
MINNESOTA	
Minneapolis	Leslie Paper
St. Paul	Inter-City Paper Co.
MISSISSIPPI	
Jackson	Sloan Paper Co.
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	Tobey Fine Papers
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	Virginia Paper Co.
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	Virginia Paper Co.
Raleigh	Dillard Paper Co.
	Virginia Paper Co.
Wilmington	Dillard Paper Co.
Winston-Salem	Dillard Paper Co.

OHIO

Cincinnati	The Diem & Wing Paper Co.
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OREGON

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Harrisburg	Alling and Cory
Philadelphia	Alling and Cory
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Pittsburgh	Alling and Cory
Scranton	Alling and Cory

RHODE ISLAND

Pawtucket	Carter Rice Storrs & Bement
Rumford	The Rourke-Eno Paper Co., Inc.

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	Southern Paper Co.
Knoxville	Dillard Paper Co.
	Southern Paper Co.
Memphis	Western Paper Co.
Nashville	Athens Paper
	Clements Paper Co.

TEXAS

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Austin	Monarch Paper Co.
Dallas	Monarch Paper Co.
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San Antonio	Monarch Paper Co.
Waco	Olmsted-Kirk Paper Co.

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Vermont

Burlington	Hudson Valley Paper Co.

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WASHINGTON

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